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**OBSERVATIONS ON THE PUPAL WINGS OF NEPTICULA,  
WITH COMPARATIVE NOTES ON OTHER GENERA.**

By ANNETTE F. BRAUN, Cincinnati, Ohio.

The Nepticulidæ possess some conspicuous characteristics not present in other Lepidoptera. The most noticeable of these are the crowding together and anastomosis of the main tracheal stems of the fore wings and the absence of true cross-veins (except the humeral cross-vein in rare instances). The nearest approach to this type of venation seems to be found among certain small Trichoptera; where however the base of media remains distinct and does not anastomose either with radius or cubitus. The presence of a true frenulum in the male in even the most primitive genera of Nepticulidæ taken in conjunction with the fact that in the female we find both jugum on the fore wing and series of hooked spines on the costa of the hind wing also suggests their relationship to the Trichoptera. Other characteristics, such as the presence of the jugum in the female of the more primitive genera, the structure of the mouth parts, and the structure of the pupa ally them to the Eriocranid group of the Micropterygidæ.

It is in the development of the venation of the fore wings that this group differs so strikingly from other Lepidoptera. The disappearance of the basal portion of media takes place through coalescence with the base of radius or with the base of cubitus, and not through atrophy as is usual in the Frenatæ.

In the hind wing media coalesces with radius to about the middle of the wing in much the same way. This condition is not however unique, as it is occasionally present in other groups

among genera with degraded venation. In some apparent examples of media coalescing with radius, a study of phylogeny within the group will show that the result is due to the atrophy of the base of media and the approximation of the remaining one or two branches of media to the radial sector.

Within the genus *Nepticula* we find two types of venation in the fore wing. In one, probably the more primitive, media coalesces with cubitus for a short distance from the base, then passes obliquely to radius just beyond  $R_{2+3}$  and anastomoses with radius to beyond the middle of the wing. In the second type, media coalesces with radius from the base to beyond the middle of the wing. In the first type, the oblique portion of media extending between cubitus and radius appears to be a cross-vein and was formerly so interpreted. The occasional persistence of the trachea within the vein cavity of the imago, and studies on the pupal wings, to be presented below, show that this oblique vein is a part of media. Its presence in the imago indicates the coalescence of media with the base of cubitus.

The present paper is based upon studies of pupal wings of two species of *Nepticula*, viz., *N. platanella*, representing the first type of venation, and *N. rosaefoliella*, representing the second type of venation. The persistence in the imagoes of some species, of the shriveled tracheæ within the vein cavities, has made possible comparisons with other genera. Pupal wings of the more generalized forms, which might have thrown some light upon doubtful homologies as noted in the presentation to follow, were not available for study. In the figures of the wings, the single more or less wavy lines represent tracheæ; the even lines enclosing them outline the thickenings which form the future veins. The figures represent the condition of tracheæ and veins a few days before the emergence of the moth.

#### FORE WINGS (Figs. 1, 2, and 3).

Except where otherwise noted, observations on *N. platanella* are based on the pupal wing illustrated by Figure 1.

*Costa*.—In *N. platanella* (Fig. 2) at a period before the developing vein cavities are clearly defined, the costal trachea is distinct. Later (Fig. 1) it is much shortened and extends

for merely a short distance into the base of the costal vein, not reaching the humeral cross-vein. In *N. rosaefoliella* (Fig. 3) no costal trachea could be distinguished.

*Subcosta*.—The subcostal trachea is distinct and branched near its tip in *N. platanella*;  $Sc_1$  (except early as shown in Fig. 2) is shriveled and curled even in the pupa, while  $Sc_2$  passes straight onward to the margin of the wing. There is no indication of branching in the subcostal vein of the imago in which trachea  $Sc_2$  extends to the end; the shriveled stump of  $Sc_1$  occasionally persists within the subcostal vein. In *N. rosaefoliella*, the subcostal trachea is unbranched, that portion persisting being  $Sc_2$ . The humeral cross-vein is easily visible in *N. platanella*, and I have found it present in all specimens examined; it passes obliquely from subcosta to costa near the base. In the imago it arises almost at the base of the wing, so oblique as almost to seem a proximal prolongation of costa.

*Radius*.—With the exception that  $R_{2+3}$  is represented by an unbranched trachea, the tracheation in *N. platanella* approaches closely to that of the hypothetical type. The tracheal stem of radius branches dichotomously, about half way between the base of the wing and the point of separation of vein  $R_1$  from the main radial stem, into an unbranched trachea  $R_1$ , and into a stem which again divides dichotomously, also before the separation of vein  $R_1$ , into a second unbranched trachea,  $R_{2+3}$  and into  $R_{4+5}$ , so that for a short distance the developing vein cavity contains three tracheal branches lying closely along side of one another.  $R_{2+3}$  follows  $R_{4+5}$  for a short distance before diverging toward the costa. A little beyond the point of separation of  $R_{2+3}$ , the trachea of  $R_{4+5}$  divides, the branches however lying close together in the same vein cavity until near the apex of the wing, where they diverge, each lying in a separate vein cavity. The relation of tracheæ to veins in *N. rosaefoliella* is in essential agreement with that observed in *N. platanella*, except that (1) the branching off of tracheæ  $R_1$  and  $R_{2+3}$  occurs at or near the point of separation of the corresponding veins and (2) there is no division of trachea  $R_{4+5}$  until very near the margin of the wing (cf. fig. 3) and but a single unbranched vein is formed.

In the imaginal wing of the European *Trifurcula*, the main stem of the persistent radial trachea divides dichotomously into

$R_1$  and  $R_{2+3}$ ; further branches of radius (both tracheæ and veins) are entirely wanting. In the adult wing of the European *Scoliaula*, the separation of vein  $R_1$  occurs at the point of origin of trachea  $R_1$ , which is very near the base; otherwise the tracheation of radius, as far as persistent, is similar to that of the pupal wings of *N. platanella*.

*Media*.—In all species of *Nepticula*, media is represented by an unbranched vein which reaches the wing margin below the apex. In the pupal wings of both species examined, a single trachea extends from base to wing margin, with no discernible trace of branching. In *N. platanella*, the basal portion of this trachea lies within the same vein cavity and alongside of the base of the cubital trachea, from which it diverges to pass obliquely to radius just beyond  $R_{2+3}$ , lying alongside of and in the same vein cavity with the radial trachea to beyond the middle of the wing where it again diverges before the separation of veins  $R_4$  and  $R_5$ , and passes to the margin of the wing below the apex. In one specimen (Fig. 2), at an earlier stage of development than that shown in Figure 1, and in which the vein cavities were not as well defined, the medial trachea does not approximate as closely to cubitus at its base, nor to radius in the middle of the wing, so that the relative positions of the basal stems of the main tracheæ approach more nearly to those of the hypothetical type. In *N. rosaefoliella*, the trachea of media lies alongside of and in the same vein cavity with radius from the base of the wing to its point of divergence from  $R_{4+5}$  beyond the middle of the wing. An intermediate condition is to be noted in *N. variella*, where media coalesces with cubitus at base, but passes to radius before the point of separation of  $R_1$ .

Because of the unbranched condition of the medial trachea it is impossible to determine with certainty the homology of the vein which it precedes.

In *Obrussa* and *Glaucolepis* media is two-branched; in the former genus, the separation of the branches occurs beyond the separation of media from  $R_{4+5}$ ; in the latter before the separation of media from radius. In *Obrussa*, the tracheæ in the imaginal wing are not sufficiently persistent for study. In *Glaucolepis*, the medial trachea is unbranched and shrivels up near the point of separation of the first of the two branches of media. However, as all of the branches of the radial trachea are distinctly

preserved along the middle of the wing, as is also the cubital trachea (which here lies alongside of media for its whole length), it might be expected that if the second branch of media were  $M_{3+4}$  it would be represented by a remnant of a trachea branching off about as far from the base as the second dichotomous division of radius, and certainly not farther distad than the separation of  $R_{4+5}$  into its branches. No such remnant is discernible and I have therefore interpreted the branches of media in these two genera as  $M_1$  and  $M_2$  respectively.

In the genera *Scoliaula* and *Trifurcula*, in the adult wing, three veins which reach the margin below the apex arise from the main vein traversing the middle of the wing, which, as shown by the persistent tracheæ within the vein cavity, is formed by the coalescence of the basal stems of the radial sector, media and cubitus in *Scoliaula*, and by the coalescence of media and cubitus in *Trifurcula*. The medial trachea so far as it persists is unbranched in both. The first two veins may without doubt, as in the previous case, be regarded as  $M_1$  and  $M_2$ , respectively. As far as any evidence presented by the tracheæ is concerned, the third vein may be either  $M_{3+4}$  or cubitus. In most other genera, as noted immediately below, cubitus tends to become obsolete before reaching the margin; if the same course of development has been followed here, the conclusion would be that the third vein is  $M_{3+4}$ .

*Cubitus*.—In *N. platanella* the unbranched cubital trachea passes almost straight from base to beyond the middle of the wing, where it becomes obsolete. As before mentioned, in the proximal part of its course, it lies within the same vein cavity as media. In *N. rosaefoliella*, the cubital trachea lies alone in a separate vein cavity. A condition similar to that in *N. platanella* is found in *Ectoedemia* and *Obrussa*; in *Ectoedemia* cubitus usually reaches to the margin, in *Obrussa* it atrophies shortly after its separation from media. In *Glaucolepis* cubitus has entirely coalesced with media in its proximal portion and with the radio-medial stem beyond. In *Scoliaula* the cubital trachea lies in the single vein cavity in which are also the medial and radial tracheæ, and from which  $R_1$  separates near the base. In *Trifurcula* the cubital trachea, which lies in the same vein cavity as media, branches dichotomously at the same distance from the base as the branching of radius; these branches persist to about the middle of the wing.

*Anal Veins.*—There are two anal veins. The first is here regarded as the homologue of the second anal vein of the hypothetical type, because of its relation to the anal furrow, because it occupies the same position as the second anal vein in other Lepidoptera, and because of its identical structure with that vein in some Trichoptera. In both species studied the trachea is distinctly visible within the developing vein cavity extending almost or quite to the end of the vein; the trachea usually persists in this vein in the imago. The third anal vein is sometimes present. In *N. platanella* it shows merely as a short spur from the base of the second anal vein, in which even in the pupa, no trachea is visible. In *Scoliaula* it is better preserved and portions of the trachea persist.

#### HIND WINGS (Figs. 4 and 5).

Observations on the pupal hind wings were confined to *Nepticula platanella*.

*Costa.*—No costal trachea was discernible. Figure 5 represents the venation and tracheation in a wing just after emergence. The costal vein is seen to be connected at the base with the subcosta, apparently by a much shortened humeral cross-vein, much as in the fore wing.

*Subcosta and R<sub>1</sub>.*—Early in pupal development the trachea of subcosta and R<sub>1</sub> are widely separated and R<sub>1</sub> leaves the radial stem very near the base, as shown in Figure 4. At emergence they are more closely approximated and enclosed within the same very broad vein cavity. A similar condition may be noted wherever the tracheae persist.

*Radial Sector and Media.*—The radial sector is reduced to a single unbranched trachea lying in its proximal half in the same vein cavity with the medial trachea. The medial trachea and vein in *N. platanella* are unbranched as is also the case in the other species and genera, except in *Glaucolepis* and *Trifurcula* where the vein is dichotomously branched. In *Glaucolepis* the medial trachea is also dichotomously branched near the base and before the separation of radius and media; one branch running into each of the branches of the medial vein. From this it would appear that the first branch of media is M<sub>1+2</sub> and the second M<sub>3+4</sub>. In *Trifurcula* the trachea is single and extends into the first medial branch.

*Cubitus*.—The cubital trachea is unbranched, and in the earlier pupa extends nearly to the wing margin.

*Anal Veins*.—At least one anal vein is present preceded by a trachea which often persists in the imago. In some species and genera, a second short anal vein is present, but no trachea persists.

The question of homology of wing veins among forms with degraded venation, as is often the case in the Microlepidoptera, sometimes presents a puzzling problem, which in many cases can only be solved by a study of pupal wings; involving as has been hinted in the above presentation of the pupal wings of *Nepticula*, a study of the more generalized as well as the most specialized wings within the group, since the tracheae show the same tendency toward reduction in number of branches as is seen in the wing veins of the imago.

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#### EXPLANATION OF PLATE XVIII.

- Fig. 1. Pupal fore wing of *Nepticula platanella* a few days before emergence.  
Fig. 2. Pupal fore wing of *N. platanella* at an earlier stage than that represented by Fig. 1.  
Fig. 3. Pupal fore wing of *Nepticula rosaeoliella*.  
Fig. 4. Pupal hind wing of *N. platanella* of the same age as the fore wing in Fig. 2.  
Fig. 5. Hind wing of *N. platanella* just after emergence.